

# Occurrence and Fate of PPCPs in Domestic Effluents used for Indirect Potable Reuse

Jörg E. Drewes, Martin Reinhard,  
Jean Debroux, Robert Arnold & Peter Fox

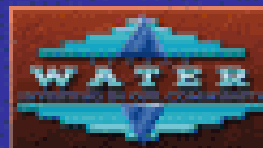


ACT Conference "Drugs in the Environment"  
November 14, 2000 San Diego, California



# Soil-Aquifer Treatment for Sustainable Water Reuse

- a tailored collaborative research study funded by



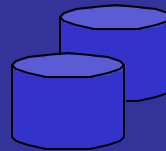
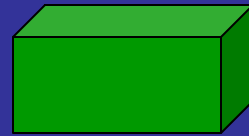
# Outline

- Introduction to Soil-Aquifer Treatment leading to Indirect Potable Reuse
- Pharmaceutical compounds of concern
- Occurrence and fate of PPCPs in water reuse systems
- Addressing potential human health effects
- Conclusions

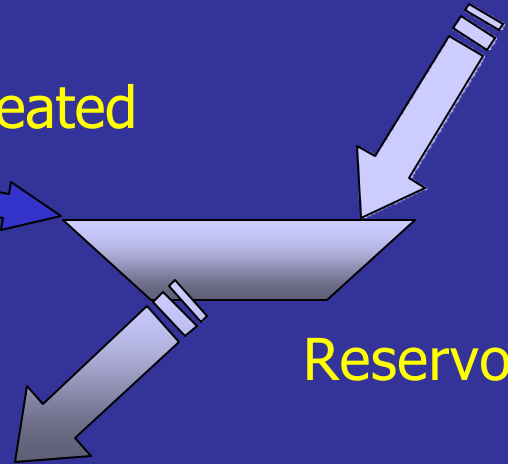
# Indirect potable reuse

## Water Reclamation

Wastewater



RO-treated

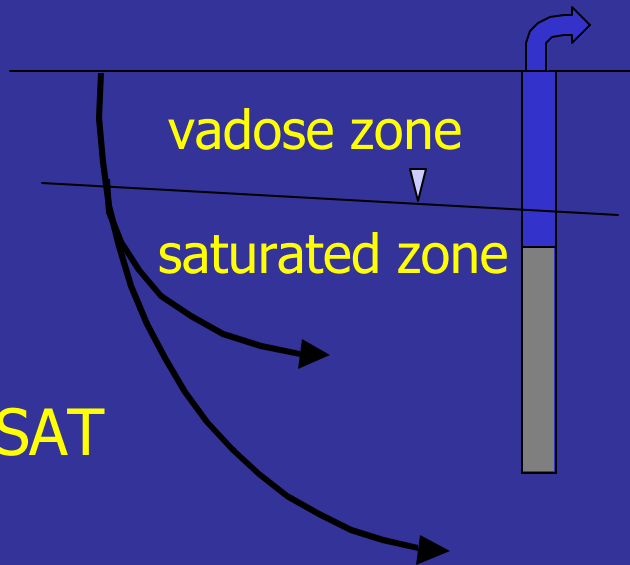


Reservoir

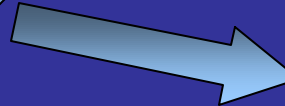
tertiary effluent



Surface spreading



Water Treatment



Consumer

# Pharmaceutical compounds of concern in potable reuse systems

Polar and nonvolatile xenobiotics, such as:

- Antibiotics
- Antiepileptics
- Blood lipid-lowering agents
- Diagnostic contrast media
  - Iodine containing X-ray contrast media  
(Diatrizoate, Iopromide et al.)

# Experimental and analytical approach

- Field studies at water reuse sites to study fate of bulk organics (i.e., total organic carbon – TOC, UV absorbance)
- Occurrence and fate of trace organics originating from PPCPs using GC/MS-screening
- Survey of domestic effluents for triiodinated contrast media
- Lab experiments to study behavior of triiodinated contrast media in engineered systems:
  - advanced wastewater treatment using ozone
  - biodegradation studies
- Fate of triiodinated contrast media in the environment

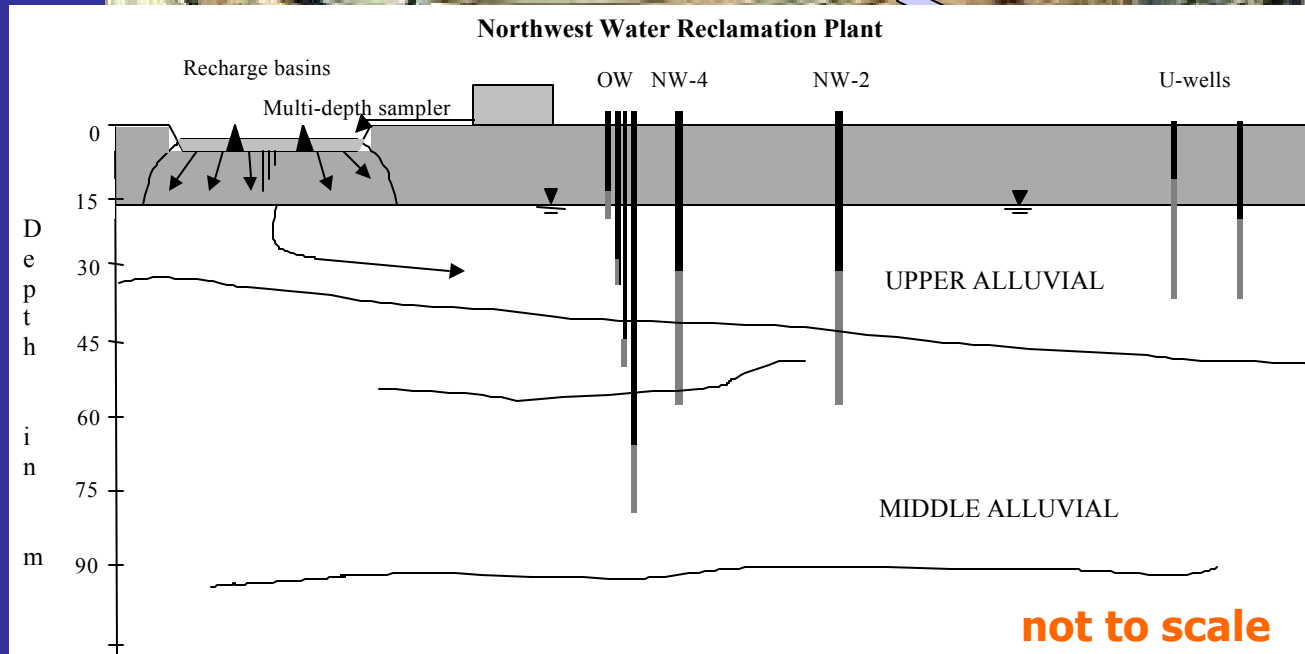
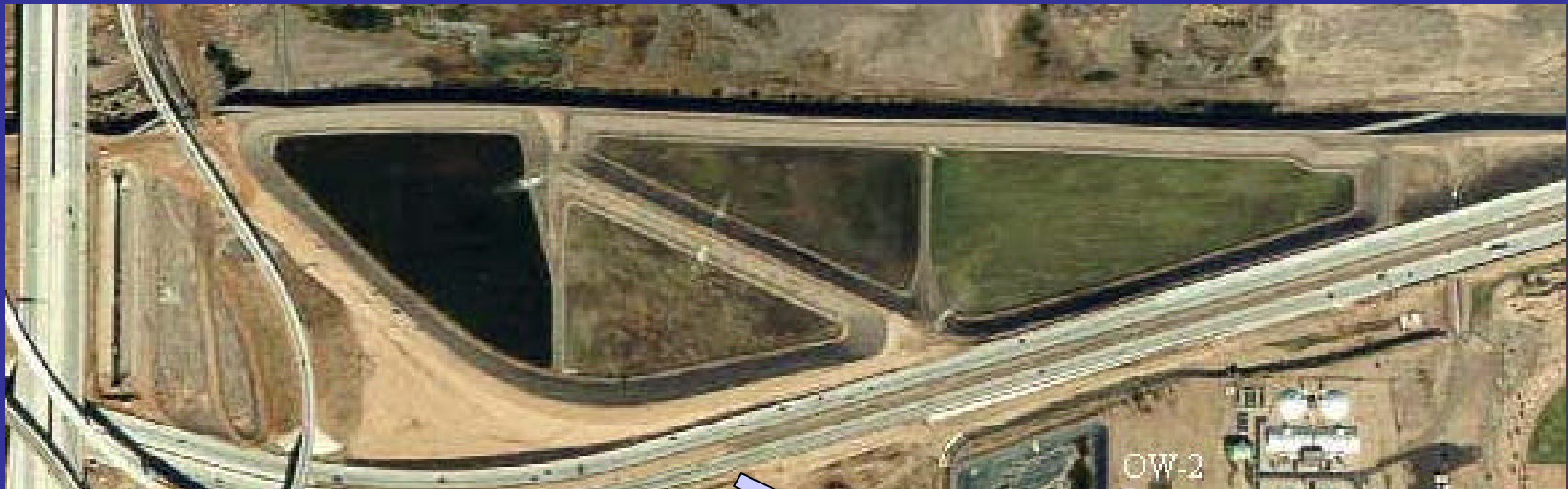
# Water reuse field sites

# Investigated water reuse field sites





# NW Water Reclamation Plant Mesa, AZ

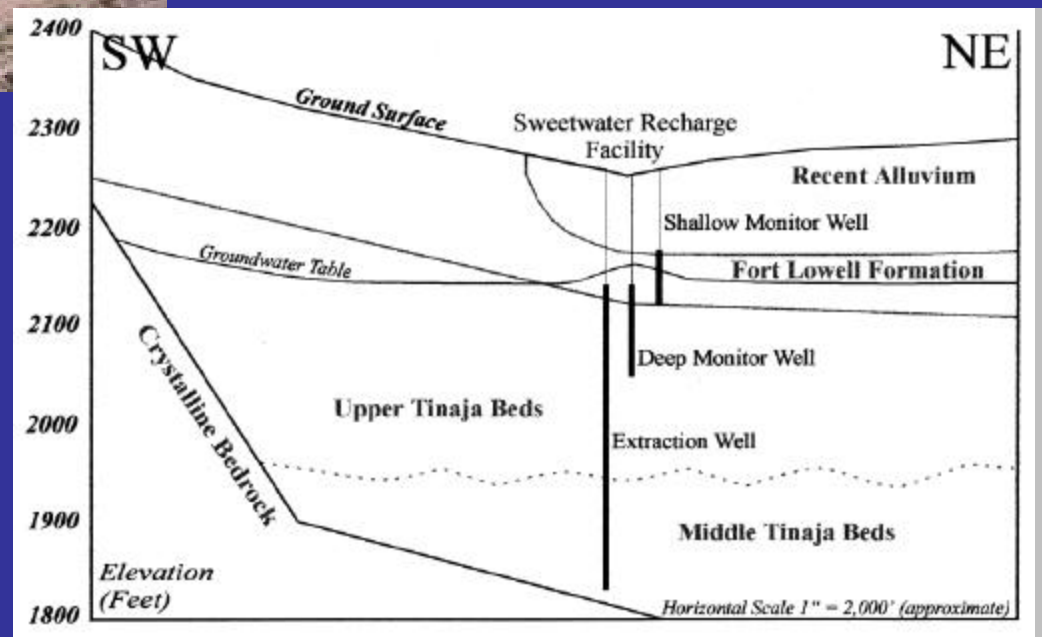


# Tucson Sweetwater Recharge Facility, AZ



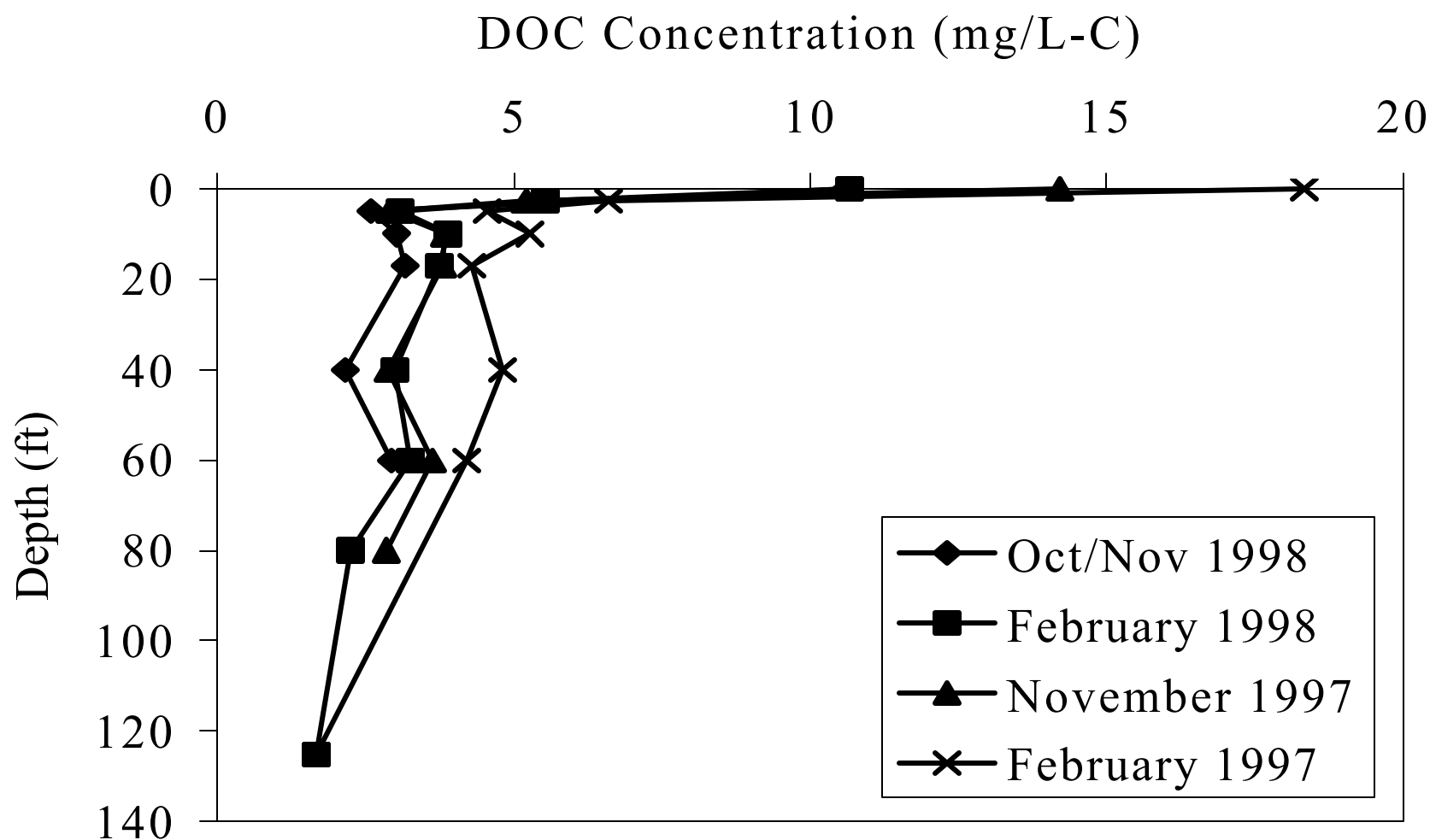
Wetlands and recharge basins

Geologic profile

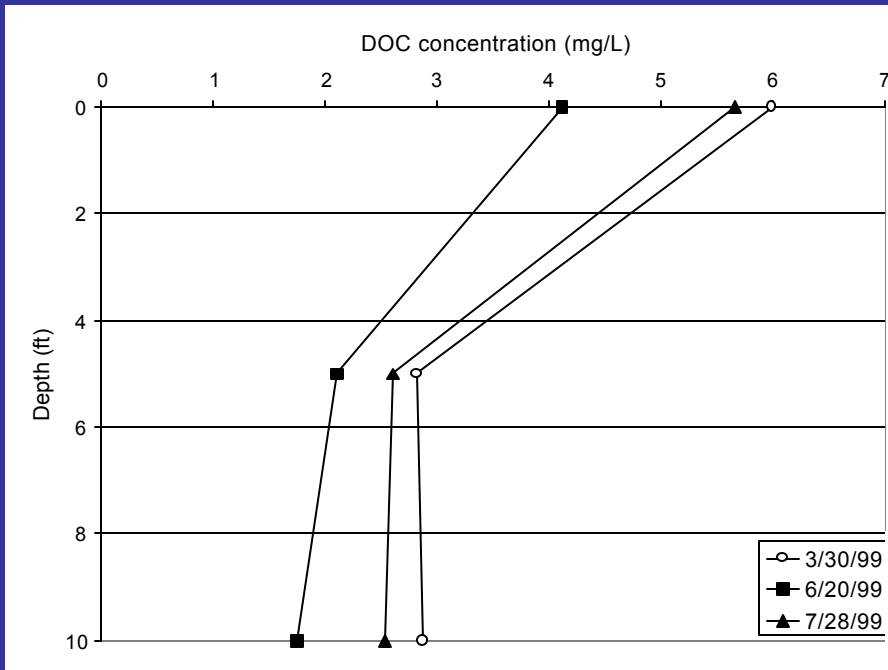


# Fate of bulk organics during soil-aquifer treatment

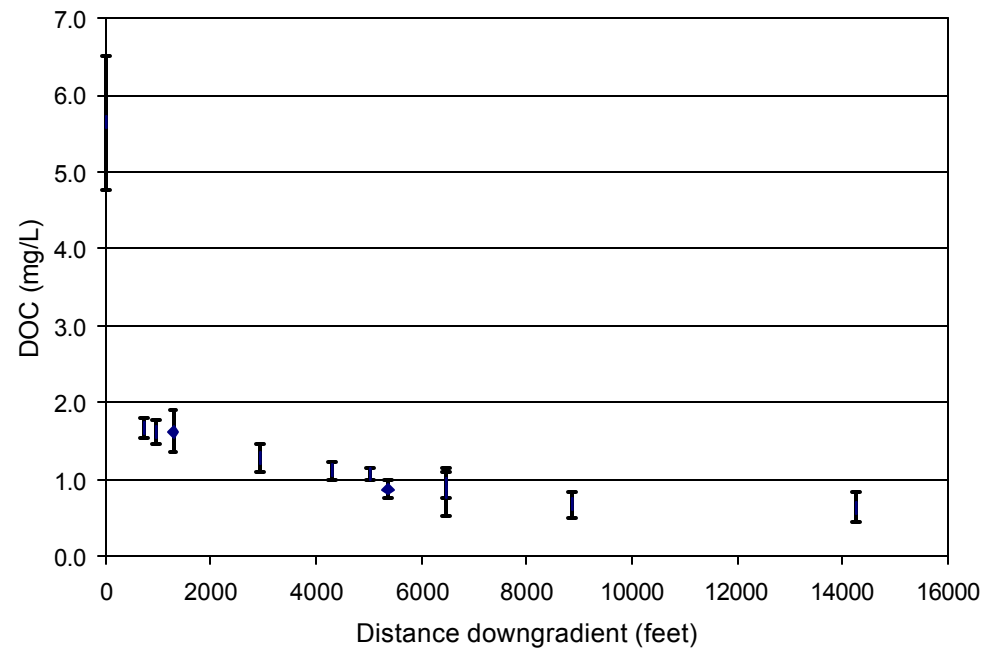
# Organics removal at Tucson SUSRF, AZ



# Organics removal at NWWRP Mesa, AZ



DOC removal during long-term SAT



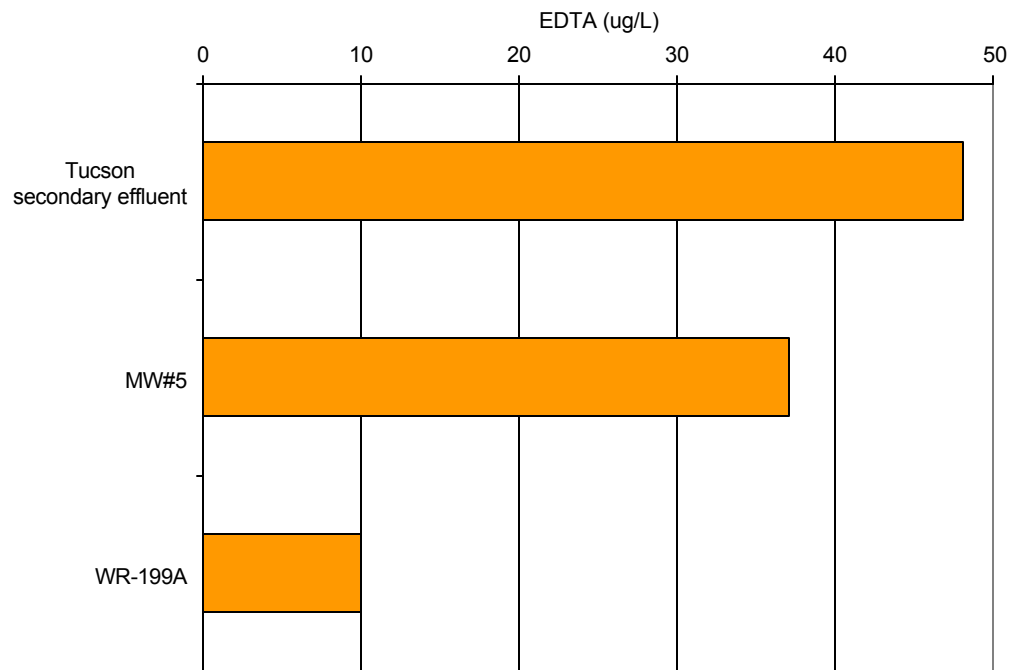
DOC removal during short-term SAT

NWWRP Mesa

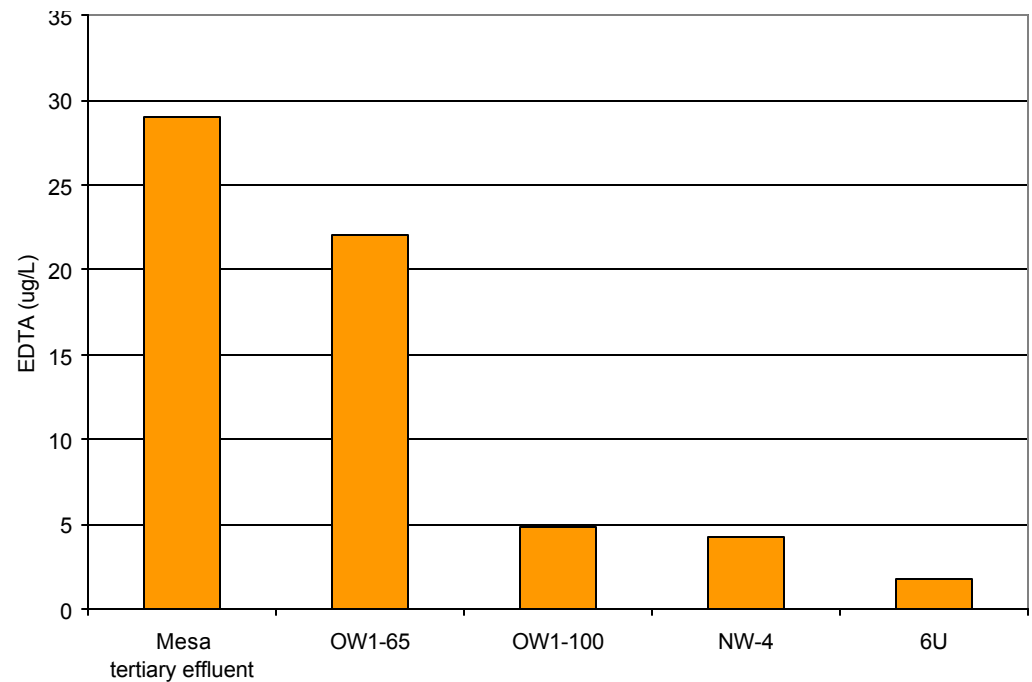
# Occurrence and fate of PPCPs

# Fate of EDTA during SAT

NWWRP Mesa, AZ



Sweetwater Tucson, AZ



# Occurrence of PPCPs based on GC/MS screening

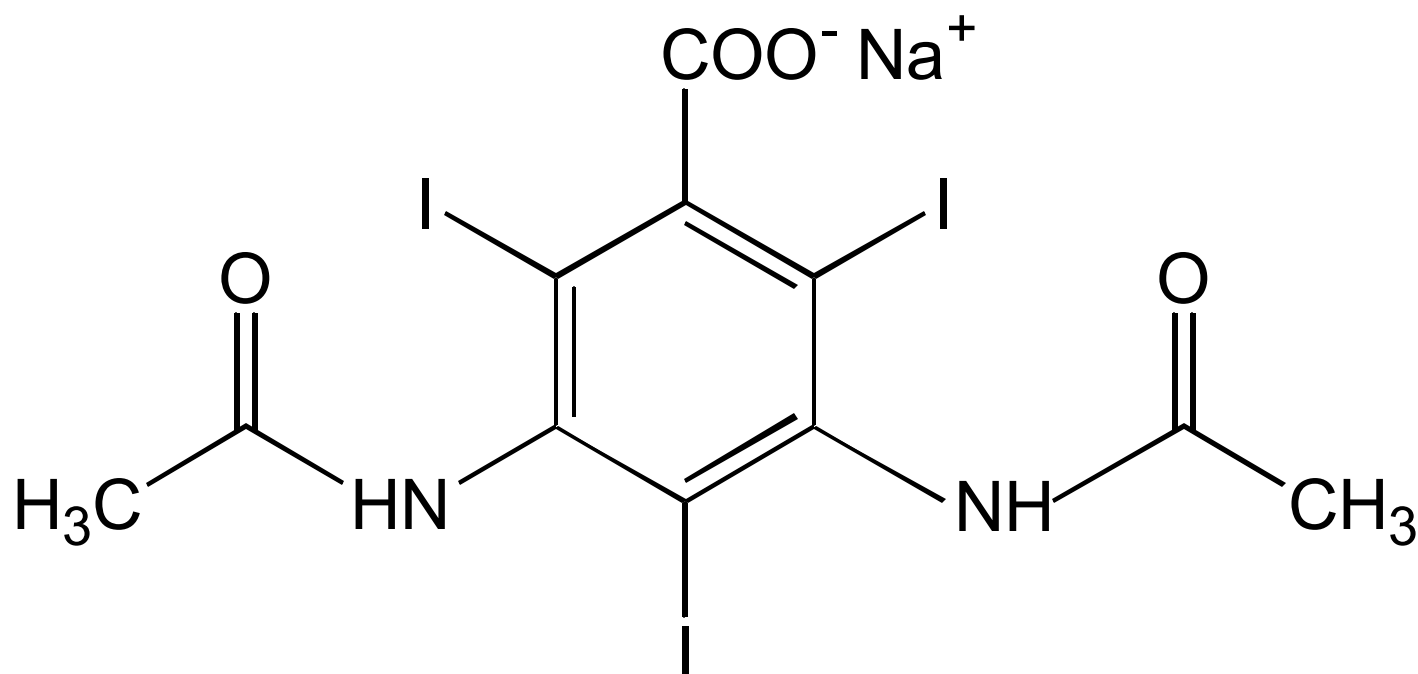
Compound	Origin	Reclaimed water	after SAT (~ 6-12 months)
2,4,5-trichlorophenol o-hydroxybiphenyl	Disinfectant	identified	
2-phenoxyethanol	Perfume production	identified	
Carisoprodol Mebromate	Muscle relaxant drug	identified	
benzothiazole	Azo-dye	identified	
N-cyclohexyl-2-pyrrolidone	Intermediate of pharmaceutical prod.	identified	
Phosphoric acid tributyl ester	Solvent, softener	identified	
N-butyl-benzenesulfonamide	Antibiotic	identified	



# Occurrence of triiodinated contrast media in domestic effluents

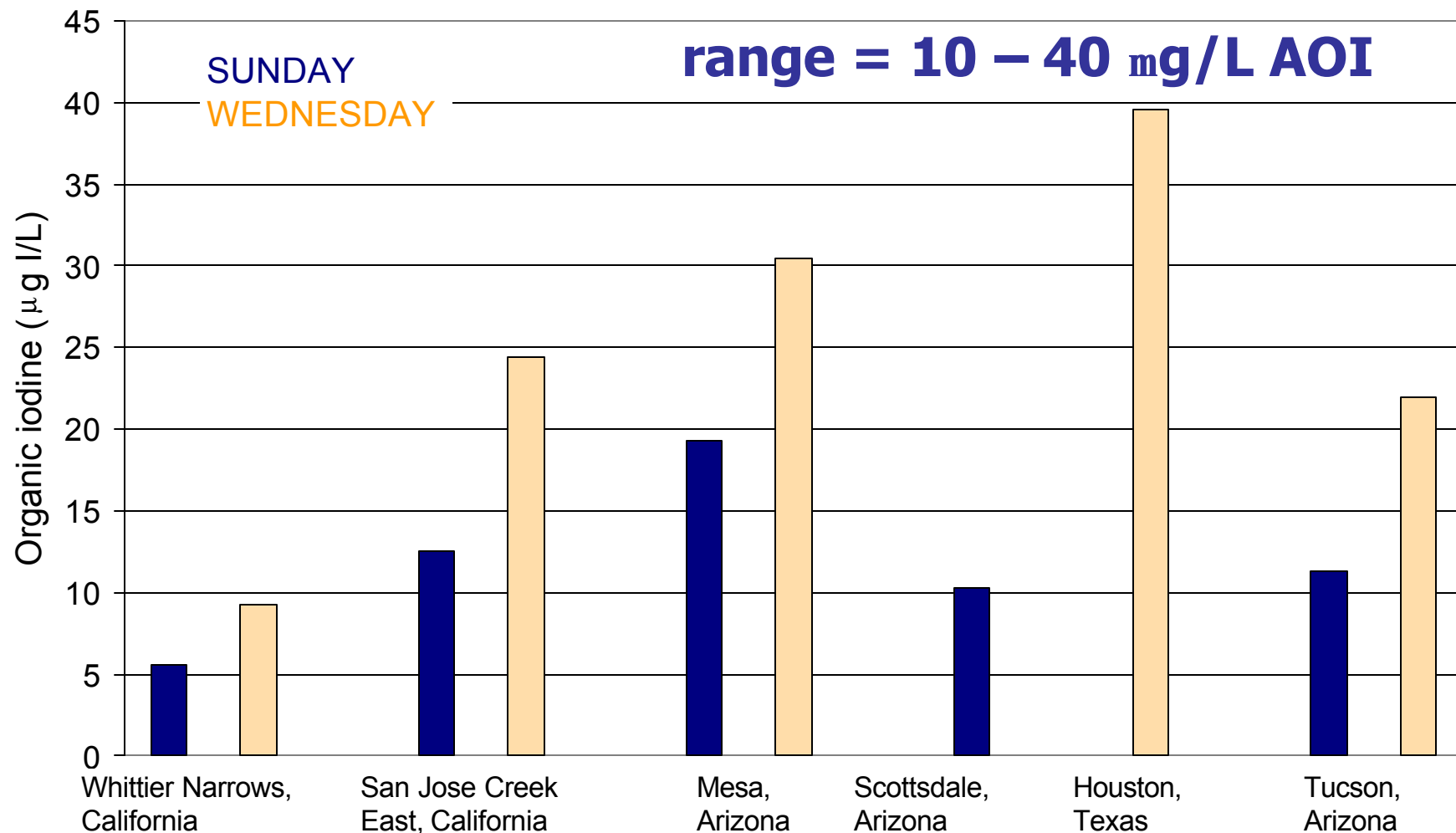
# Triiodinated X-ray contrast media

Diatrizoate (Na)

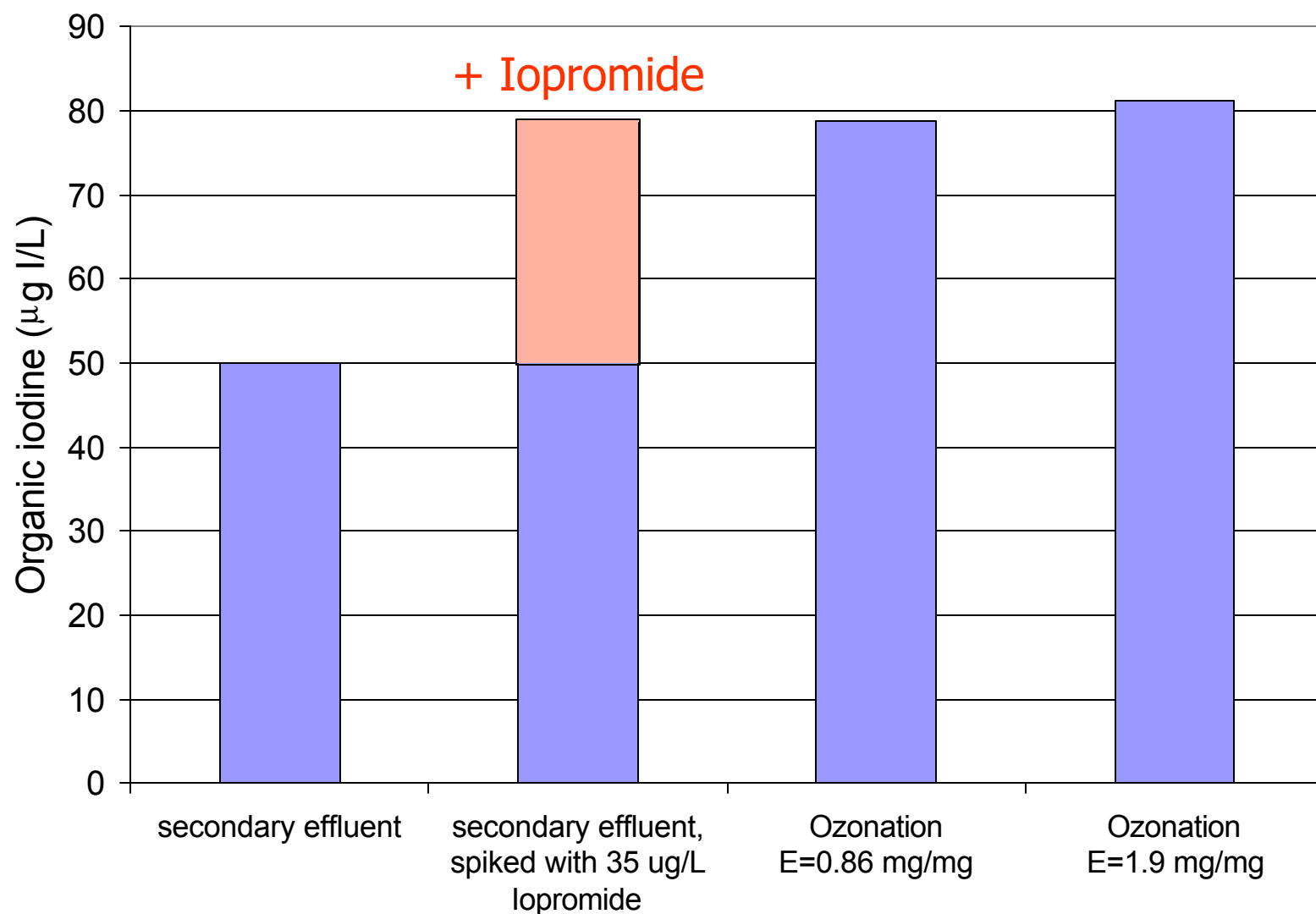


3,5-Bis(acetylamino)-2,4,6-tri-iodobenzoic acid sodium salt

# Occurrence of organic iodine in domestic effluents

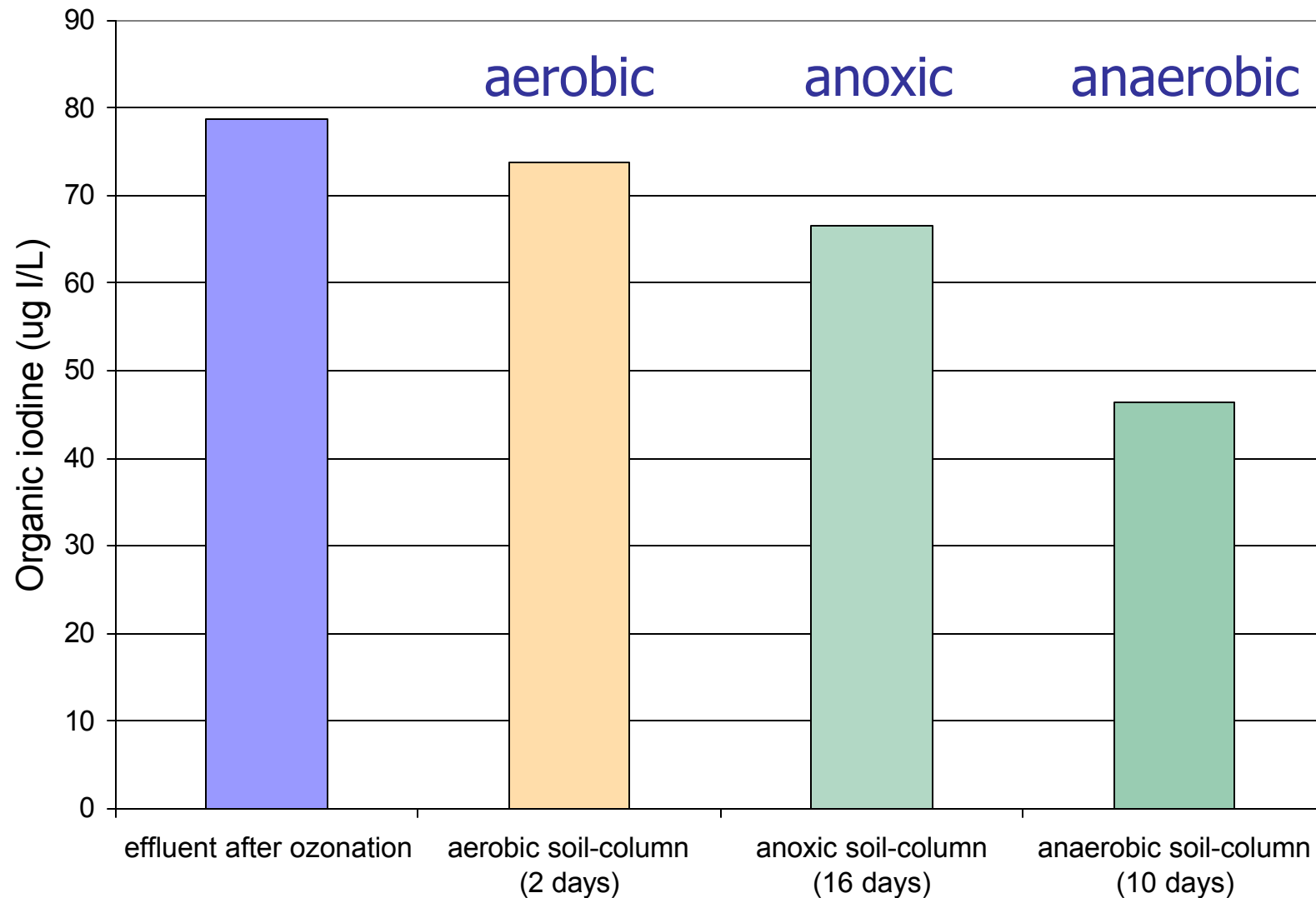


# Advanced wastewater treatment: Ozonation of spiked effluents



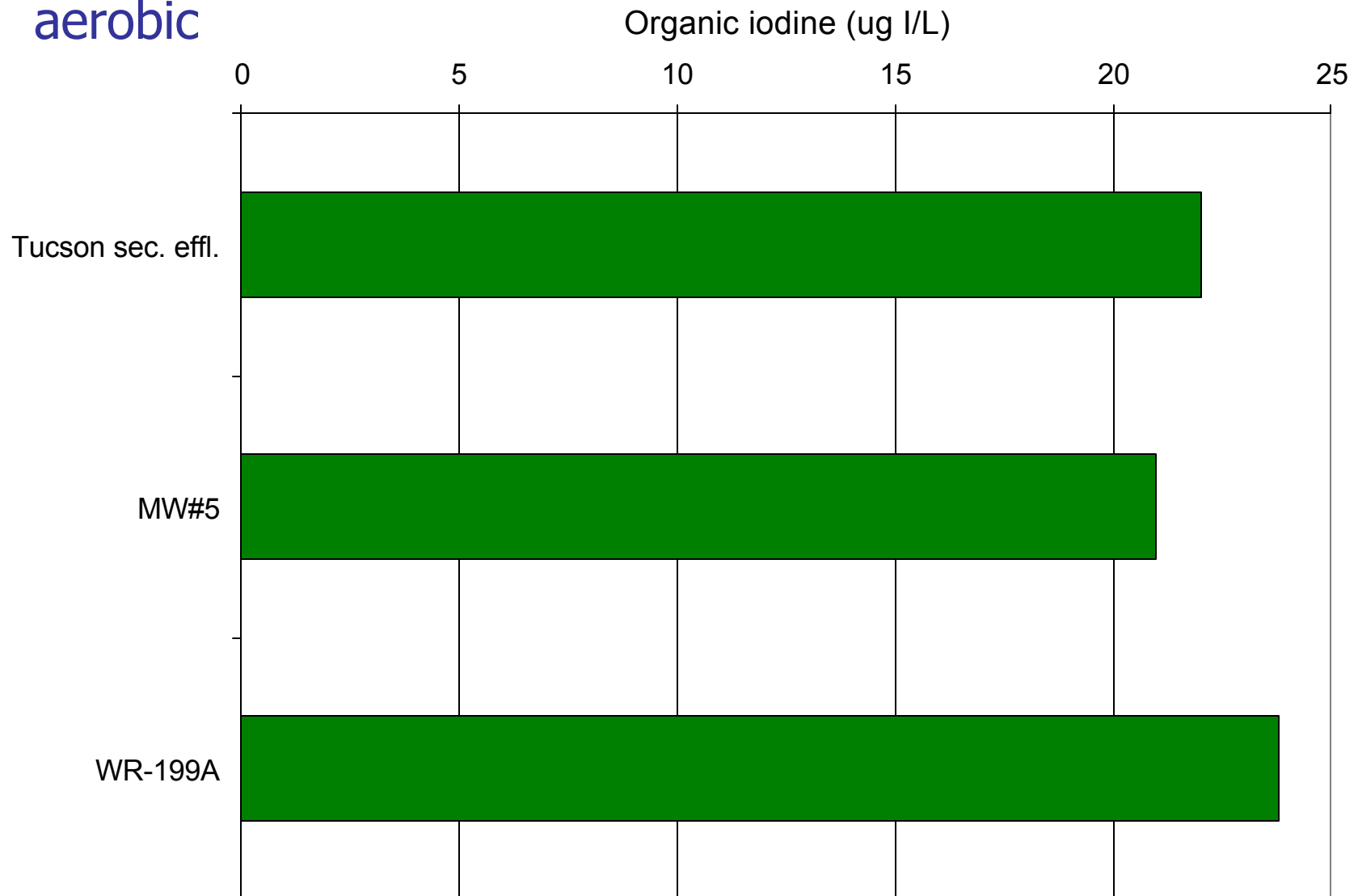
# Fate of organic iodine during groundwater recharge

# Biodegradability studies under various redox conditions

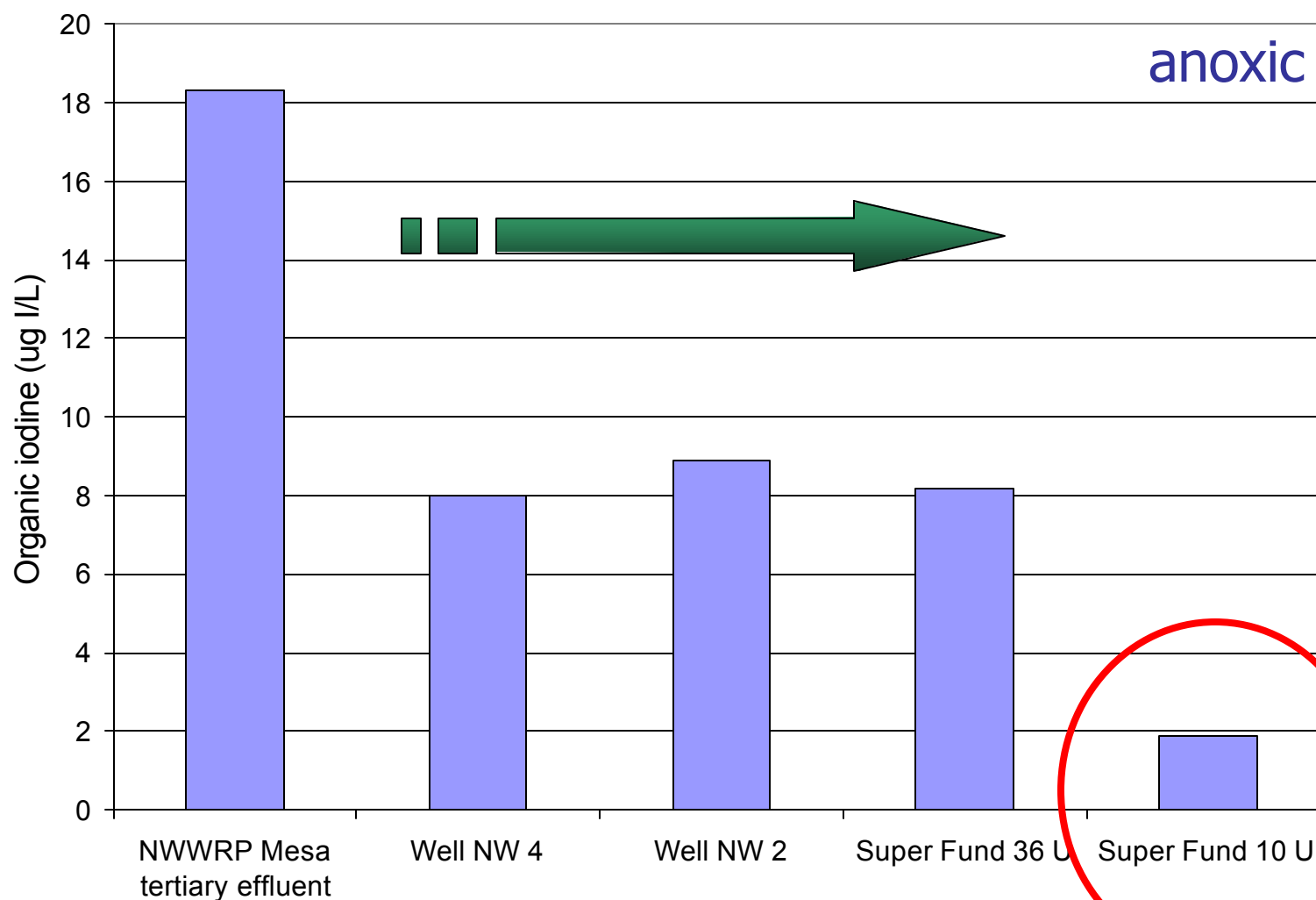


# Fate of organic iodine compounds during aerobic SAT

aerobic

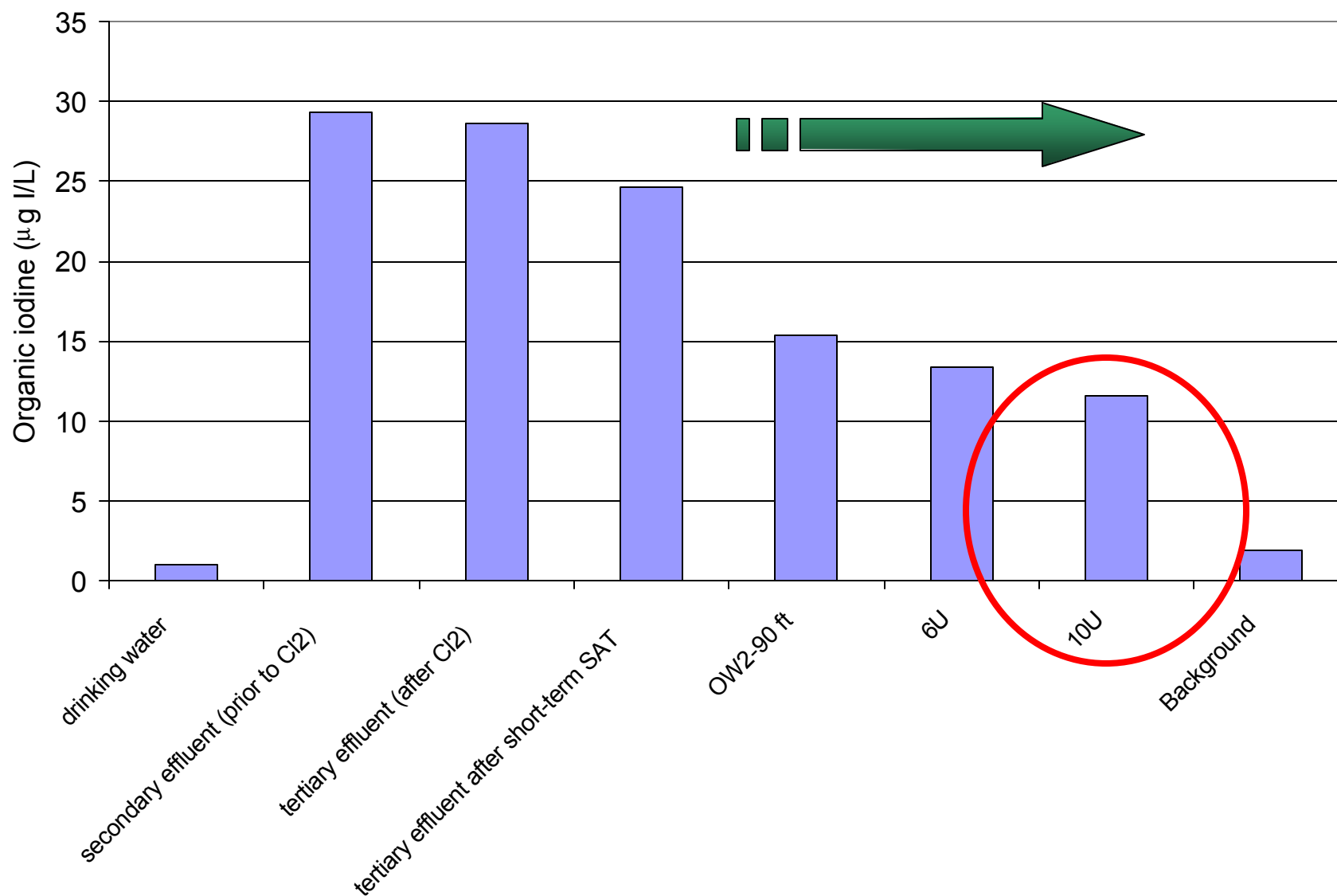


# Fate of organic iodine compounds during anoxic SAT (1997)

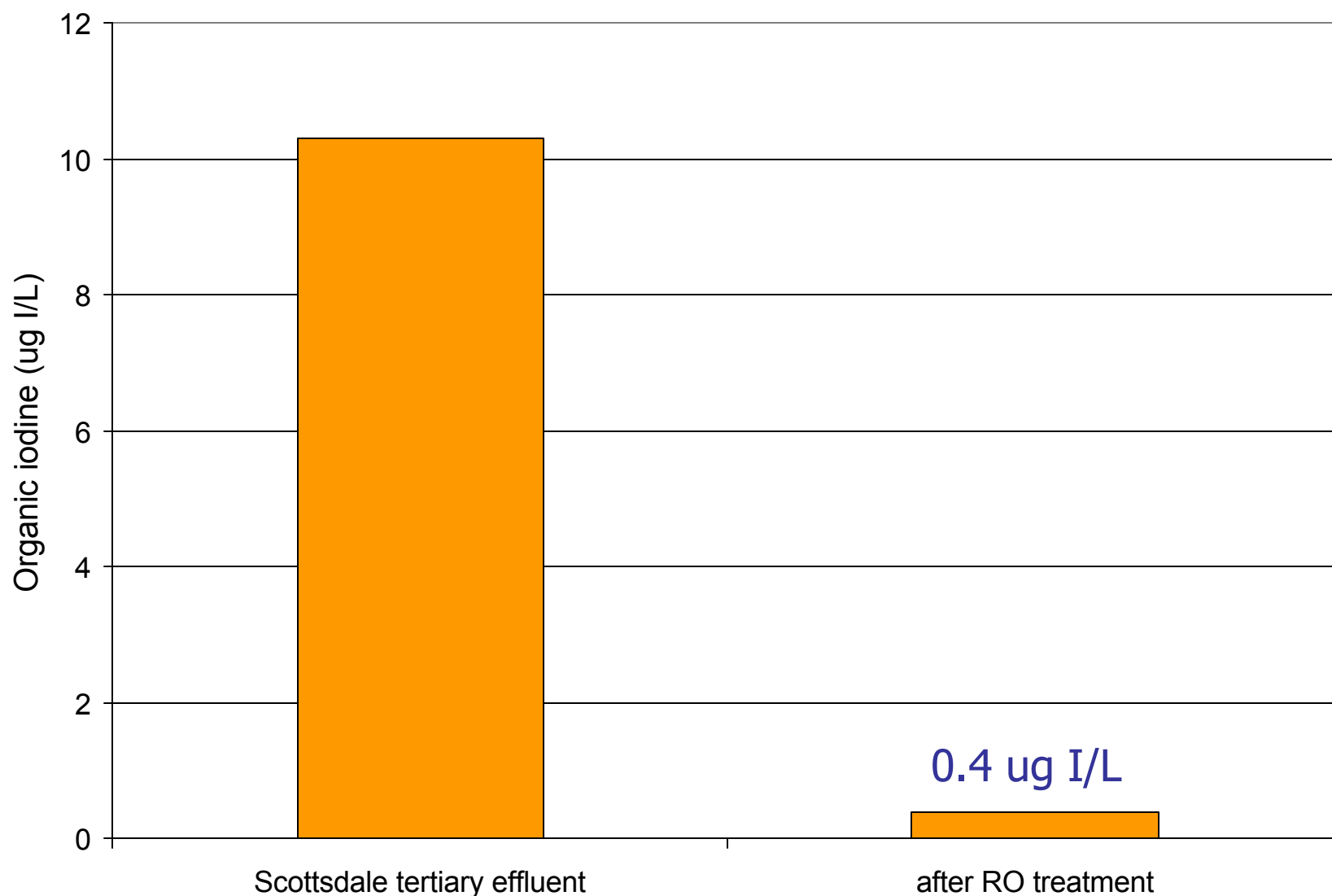




# Fate of organic iodine compounds during anoxic SAT (2000)

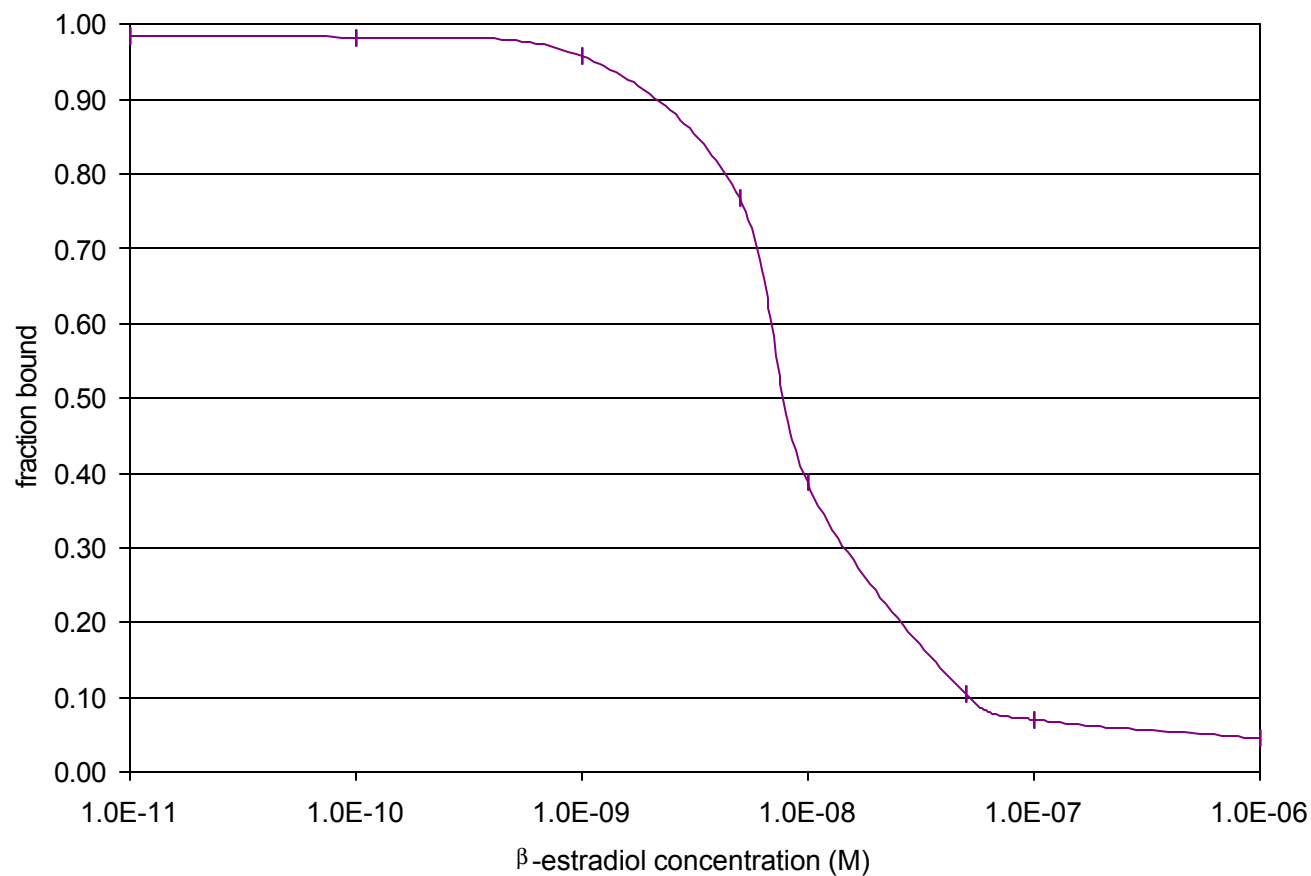


# Fate of organic iodine compounds during advanced wastewater treatment



Addressing potential  
human health effects

# Fluorescence Polarization (FP) Assay



Fluorescent ligand = labeled estrogenic compound

Non-labeled ligand =  $\beta$ -estradiol

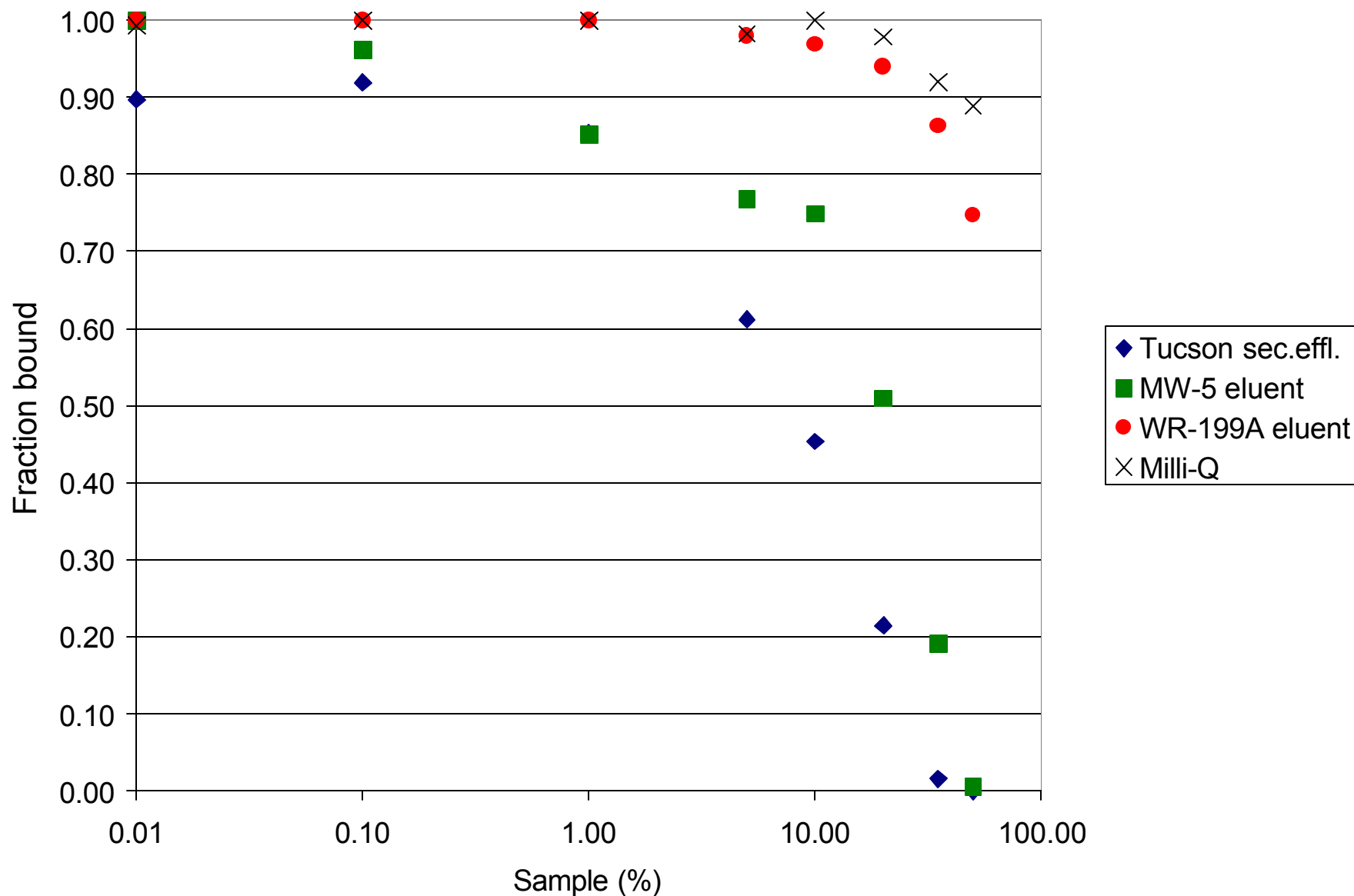
$\lambda$  excitation = 360 nm

$\lambda$  emit = 530 nm

# Endocrine disruption assay using bulk water samples

Field site	Endocrine disruptor assay
Mesa drinking water	Negative
Mesa tertiary effluent	Negative
Mesa tertiary effluent after long-term SAT	Negative
Tucson secondary effluent	Positive
Tucson sec. effluent after SAT (shallow well - MW#5)	Positive
Tucson sec. effluent after SAT (deep well)	Negative
Rio Hondo tertiary effluent	Negative
Rio Hondo tert. effluent after SAT (RH-1A)	Negative
Scottsdale secondary effluent	Negative
Scottsdale secondary effluent after RO	Negative

# Receptor binding assay using C-18 eluents



# Conclusions

- Selected PPCPs were identified in reclaimed water only. During SAT, only organic iodine compounds persist
- Organic iodine compounds from contrast media can accumulate in the environment
- Negligible removal during wastewater treatment
  - AOI concentrations in US effluents 10-40  $\mu\text{g/L}$
  - AOI concentrations in German effluents 20-110  $\mu\text{g/L}$
- Only partly removal during groundwater recharge, remaining AOI concentration after long-term soil-aquifer treatment 10–15  $\mu\text{g/L}$
- Toxicological effects of remaining metabolites are unknown

Any  
questions?

